Universidade do Minho
Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

SENSING COMPLEX ENVIRONMENTS WITH LOCALIZATION REQUIREMENTS

António Júlio Pires, Paulo Mendes, Sérgio Monteiro
Centro Algoritmi, Department of Industrial Electronics Engineering
E-mail: ID2512@uminho.pt

KEYWORDS
Smart Sensors, Wireless Sensor Networks, UWB, indoor location

ABSTRACT

Two areas that are at present being developed, are smart materials and smart environments. This intelligence is based on the ability to measure and collect various distributed physical variables. This information is acquired, collected and transmitted by wireless sensor networks. Of the many known technologies such as IEEE802.15.1 (Bluetooth), IEEE802.15.4 (Zigbee) and 802.11 b/g/n (Wi-Fi), one that has been widely implemented for sensing purposes, is the Zigbee. However, this type of technology can become quite inefficient when the network size increases. A solution that can satisfy the wireless sensor networks requirements and in recent years has aroused great interest in the community is Ultra Wideband technology, and its development started a new era in short and very short range communications. In this work, the Ultra Wideband will be explored as a solution to deploy complex (high throughput, high node number, non-homogeneous traffic) wireless sensor networks with location requirements.

INTRODUCTION

Since there is a tendency for a higher temporal and spatial resolution, sensor networks have an increasing complexity due to the high number of sensors that are expected in a particular environment.
Also the fact that this information is dependent on where it is collected, it is of utmost importance to have accurate information about the exact location of the sensor, which is still quite complex when it comes to indoor environments.
The application of Ultra Wideband (UWB) technology, due to its many benefits, in particular: the low cost of transceivers, the ability to communicate at high speeds with high throughput and spatial resolution for very short distances; it is an asset to the continued development of wireless sensor networks (WSN), having received much attention in recent times, both from industry and academia (Shen, Guizani et al. 2006).

STATE-OF-THE-ART

Beyond the most common technologies such as IEEE802.15.1, IEEE802.15.4 and 802.11 b/g/n (Lee, Su et al. November 2007), there is also a proposal for WSN with very low consumption, known as DUST. But they can be very inefficient for several reasons (Mansouri, Sardouk et al. December 2010).
WSN also got requirements for node geolocation, with a high degree of accuracy. Using the most common sensor networks such as Zigbee, it is not possible to obtain a good spatial resolution.
Currently, most WSN are based on transmission schemes for narrowband, so beyond the number of nodes running at the same time be very limited, the solutions used for geolocation does not give the necessary accuracy for very short distances. However, the UWB use very high signal frequencies (in the order of GHz) allowing a higher temporal resolution and high accuracy for short distances. Given also a solution that in recent years has aroused great interest in the community is UWB technology, and its development started a new era in short and very short range communications (Kraemer and Katz 2009).

Requirements for WSN and UWB technology applicability

In WSN the transceivers with sensors, spatially distributed, are used to carry out monitoring of environmental conditions in different locations. The main objective of the network is to communicate the sensor data, taking into account constraints of delay and

reliability. The requirements for the transceivers in a WSN are given by the standard Zigbee: low cost (for mass production), small size e low consumption.
Some additional requirements are necessary to make effective the WSN: robustness, variable data throughput e heterogeneous network.
Apart from data communication, geolocation is another key aspect for many applications of WSN. The UWB technology can give an answer to all of these requirements.

Comparison between existing technologies

When a parallel is made between the several technologies for WSN, UWB offers significant advantages with respect to robustness, power consumption and precision geolocation, as shown in Table 1.

Tabel 1 – Comparison between the various wireless technologies (Lee, Su et al. November 2007)

	2.4 GHz Zigbee	2.4 GHz Bluetooth	2.4 GHz Wi-Fi	UWB
Throughput	Low (250 kbps)	Average (1 Mbps a 3 Mbps)	High (11 Mbps for 802.11b; 100+ for 802.11n)	Average (mandatory 1Mbps; up to 27MHz for 802.15.4a)
Transmission range	Short (< 30 m)	Short (< 10 m)	Long (> 100 m)	Short (< 30 m)
Geolocation accuracy	Low (few meters)	Low (few meters)	Low (few meters)	High (< 50 cm)
Energy consumption	Low (20 mW to 40 mW)	Average (90 mW)	High (500 mW to 1 W)	Low (30 mW)
Multipath performance	Weak	Weak	Weak	Good
Resilience interference	Low	Low	Average	High with complex receivers; Low with simple receivers
Interference with other systems	High	High	High	Low
Complexity and cost	Low	Average	High	Are possible low, medium and high

UWB FOR WSN

The first step of the work was to perform a survey of existing UWB technology, to verify its appropriateness and applicability in WSN, specifically in complex sensory and high-density materials and intelligent environments. For this, it becomes necessary to check and study the mathematical theory involving the UWB technology, considering some previous studies.
However, only the use of physical devices allows real proof and correct measurement of the key parameters, such as checking the accuracy of detection distances of less than 5m. To do so, there will be some study and tests of UWB technology available devices, including: UWB Radar Evaluation Kit GZ6EVK from Geozondas, P220 Evaluation Kit and P400 RCM Development Kit from Time Domain.
It is intended to carry out the implementation of COTS components, in conjunction with other technologies such as Zigbee and WiFi.
It is necessary to provide a reasonable QoS for wireless communications as well as a geolocation immune to environmental dimension and noise.

CONCLUSIONS

Despite the several technologies that are used for WSN, limitations still remains at various levels, such as the number of nodes, data rate and distance. Due to the nature of signal used for wireless communications, they cannot use their own communication signal to check the distance between nodes, with great precision.
Recognizing the great interest, there are several concepts for WSN based on UWB, bringing great benefits to industry, government and military applications, emerging applications of location and imaging of objects and environments, surveillance video, sensor networks for vehicles, monitoring of outdoor sporting activity, monitoring of highways, bridges and other civil structures.

REFERENCES

Kraemer, R. and D. M. Katz, Eds. (2009). Short-Range Wireless Communications - Emerging Technologies and Applications, Wiley.

Lee, J.-S., Y.-W. Su, et al. (November 2007). A Comparative Study of Wireless Protocols: Bluetooth, UWB, Zigbee, and Wi-Fi. The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON). Taipei, Taiwan: 46-51.

Mansouri, M., A. Sardouk, et al. (December 2010). Factors that May Influence the Performance of Wireless Sensor Networks. Smart Wireless Sensor Networks. H. D. Chinh and Y. K. Tan.

Shen, X. S., M. Guizani, et al., Eds. (2006). Ultra-Wideband Wireless Communications and Networks, John Wiley & Sons.

Willig, A. (May 2008). "Recent and Emerging Topics in Wireless Industrial Communications: A Selection." IEEE Transactions on Industrial Informatics Vol. 4(No. 2).

AUTHORS' BIOGRAPHIES

ANTÓNIO JÚLIO PIRES born in Oporto, Portugal. He went to the Modern University of Oporto, where he studied Automation and Control Engineering, obtained his degree in 2000. In 2006 he obtained the MSc degree at Oporto University in Electrotechnical and Computer Engineering. Since 2007 he is a teacher of microcontrollers and home automation at the Politecnic Institute of Viana do Castelo, Portugal. His e-mail address is : juliopires@estg.ipvc.pt.